

NASA TECH BRIEF



NASA Tech Briefs are issued to summarize specific innovations derived from the U.S. space program, to encourage their commercial application. Copies are available to the public at 15 cents each from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Evaluation of Superconducting Magnets, a Study

A study was carried out to develop analytically the steady state behavior characteristics of composite superconductors and to verify these characteristics experimentally. Details of this study are presented in a report.

The first part of the report deals with the analysis of the behavior of a composite superconductor consisting of the superconductor itself and a highly conducting substrate in which all gradients along the conductor are neglected (zero-dimensional analysis). It begins with the simplest case of a conductor exposed to a coolant which is assumed to have a heat transfer characteristic represented by a constant heat transfer coefficient. Even with this restriction, this simple analysis is quite general, since the standard technique of using the heat transfer coefficient corresponding to the particular heat flux at each point can be readily applied if the heat transfer coefficient varies with heat flux. Following this analysis, the effect of the transition from nucleate to film boiling is investigated, and a general steady state stability map is developed which is very useful in understanding the conductor characteristics. The effect of poor thermal contact between the superconductor and the substrate as well as any temperature gradients in the superconductor itself are shown to be destabilizing effects, and lead to the conclusion that small superconducting filaments are desirable because of the increased area of contact as well as the reduced temperature gradients in the superconductor. In most of the zero-dimensional analyses an additional heat source is included for generality. This is done because heaters can be used very effectively as diagnostic tools, and also defects and joints can usually be represented as local

heat sources.

Following the zero-dimensional analyses, a one-dimensional model in which gradients along the conductor are taken into account was analyzed. This begins with a constant heat transfer coefficient and analyzes the behavior of a conductor with a local heat source. The conditions required for a local heat source to produce only local resistive regions are investigated in detail, and the effect of the transition from nucleate to film boiling is also considered.

Both the zero-dimensional as well as the one-dimensional analyses assume heat transfer to a coolant which can convect heat away. In either of these cases it is not possible to conduct heat to a distant heat sink without very large temperature gradients. In one dimension, the temperature drops linearly between the heat source and the heat sink, and in two dimensions it drops as the natural logarithm of the distance. It is only in three dimensions that conduction cooling alone can result in steady state solutions for finite amounts of heat generated. The case of three-dimensional heat transfer was investigated, and the special case of only conduction cooling was solved.

The two-dimensional case was formulated, but did not reduce to the simple meaningful results as in the case of one and three dimensions.

In addition to some preliminary experiments which are described in the report, the main experimental part of the program was aimed at verifying the predictions of the analytical model. Specifically, tests were run on single wires heated locally to verify the results obtained in the one-dimensional analysis.

(continued overleaf)

Another series of tests involved the behavior of a 6-inch-diameter coil wound with a square copper stabilized Nb-Ti conductor. This coil was instrumented with heaters in the windings, and was operated in helium at various pressures and temperatures. A complete stability map was determined for this coil.

Note:

Copies of the report may be obtained from:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama 35812
Reference: B68-10396

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Z. J. J. Stekly, R. Thome,
E. Lucas, B. P. Strauss,
and F. Di Salvo
of Avco Everett Research Laboratory
under contract to
Marshall Space Flight Center
(MFS-14808)